Repeatability of Embroidered Patch Antennas

***Abstract*---**The repeatability of the embroidery technology in fabricating wearable antenna is discussed in this paper. Two groups of rectangular microstrip antennas have been embroidered by conductive threads with different stitch spacings. Each group contains 8 identical antennas with 16 antennas in total. The repeatability of resonate frequency, bandwidth, gain, antenna efficiency, radiation pattern and cross-polarization are measured for different stitch spacings. The results demonstrate the potential of applying embroidery to antenna mass manufacture.

***Notes for the presentation*---** the Slide 2 describes the motivation of this study. Embroidery is wildly used in textile industry and it can create complex patterns or shapes. We made embroidered textile wearable antennas by standard embroidery machine. The repeatability is important in manufacture due to the quality control issue. Therefore we made 16 embroidered antennas and tested their repeatability. Slide 3 and 4 show the repeatability of antennas gain and radiation patterns respectively. The embroidery provides reasonable consistency on antenna fabrication.

Repeatability of Embroidered Patch Antennas

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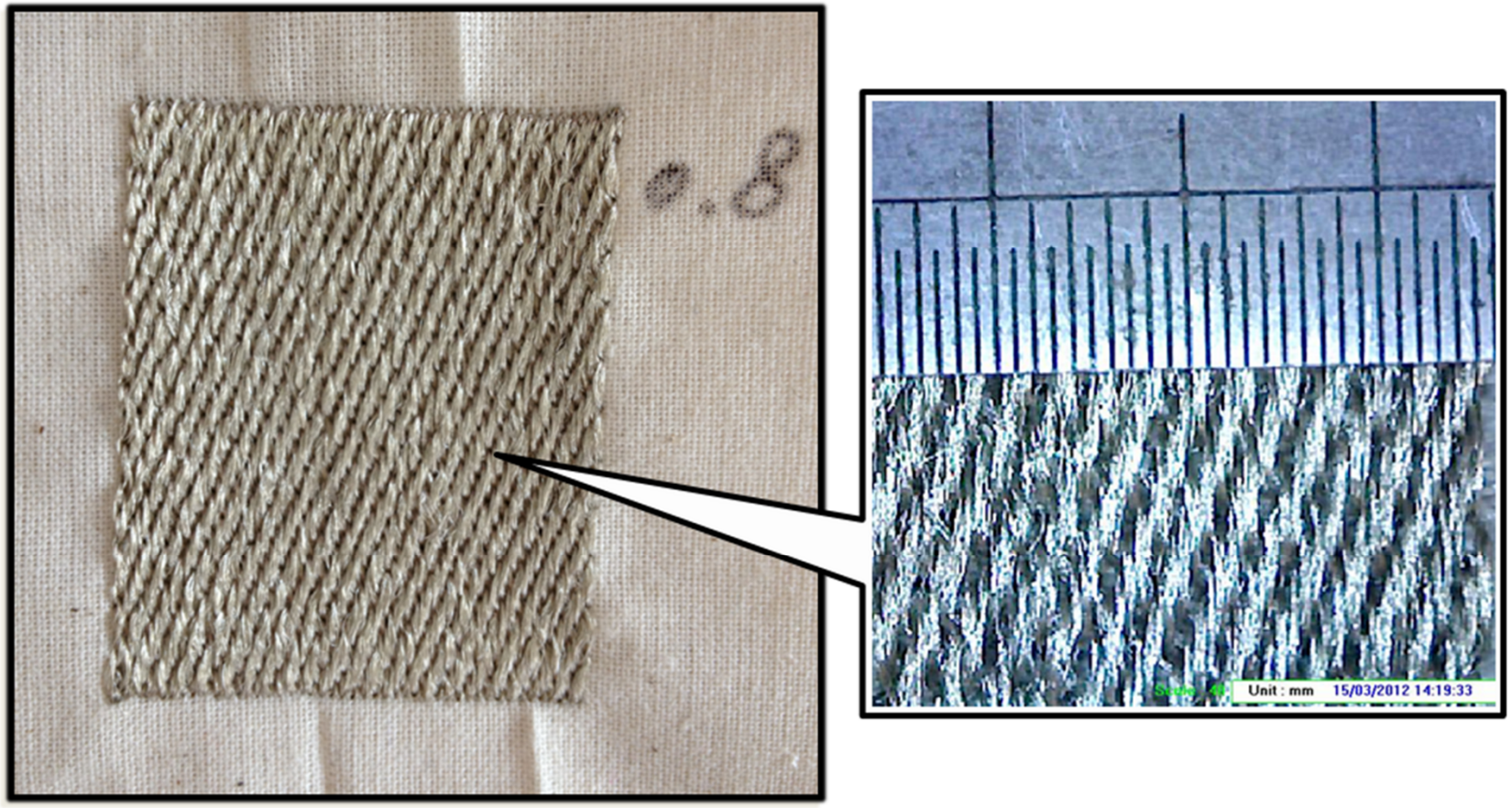
Motivation



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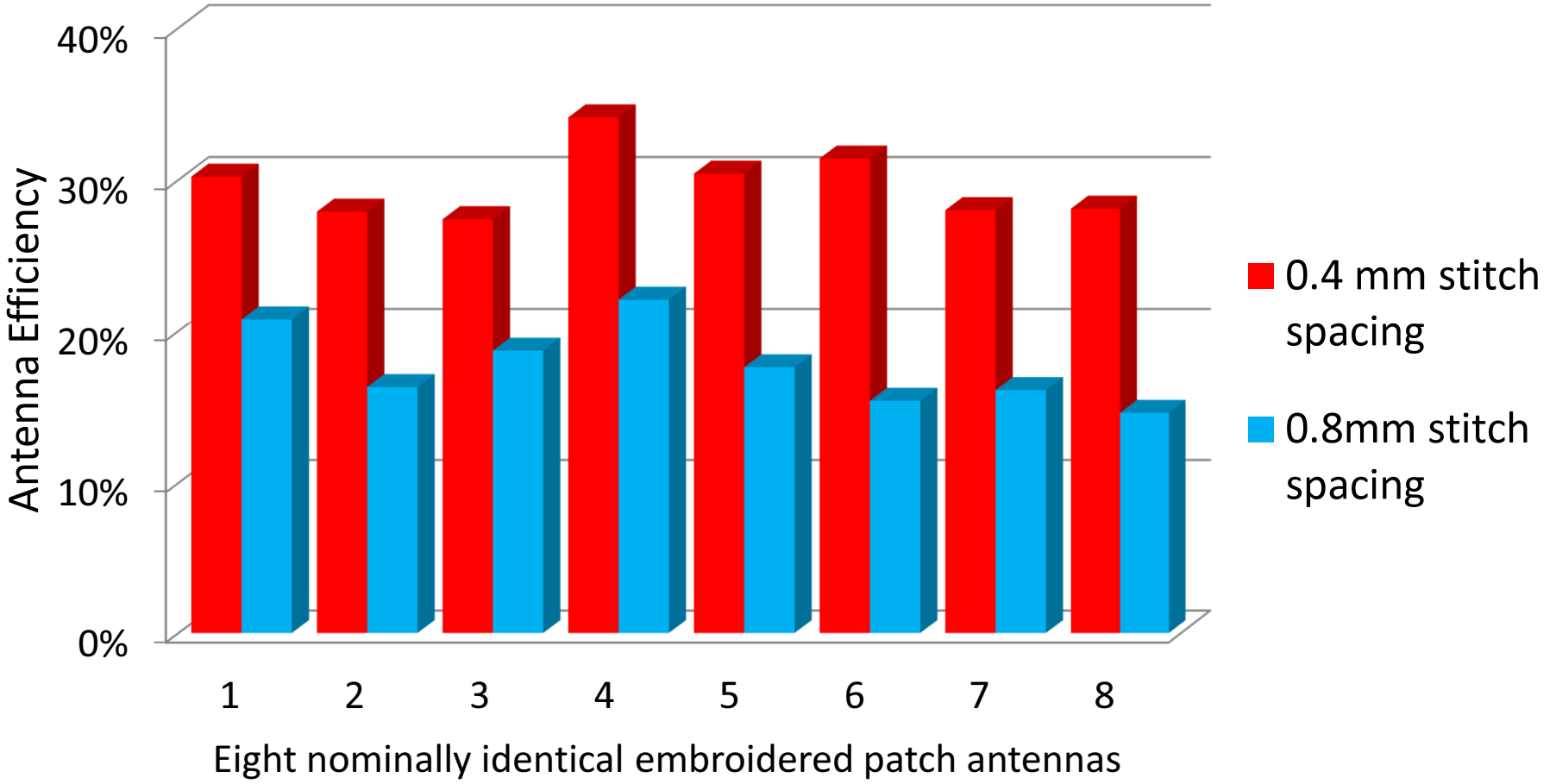
Embroidered antennas efficiencies



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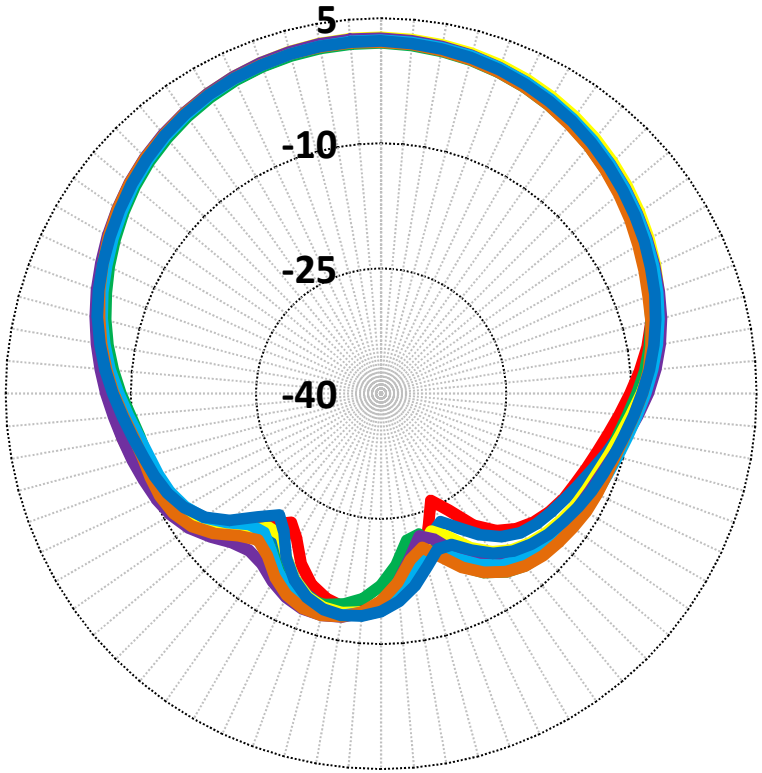
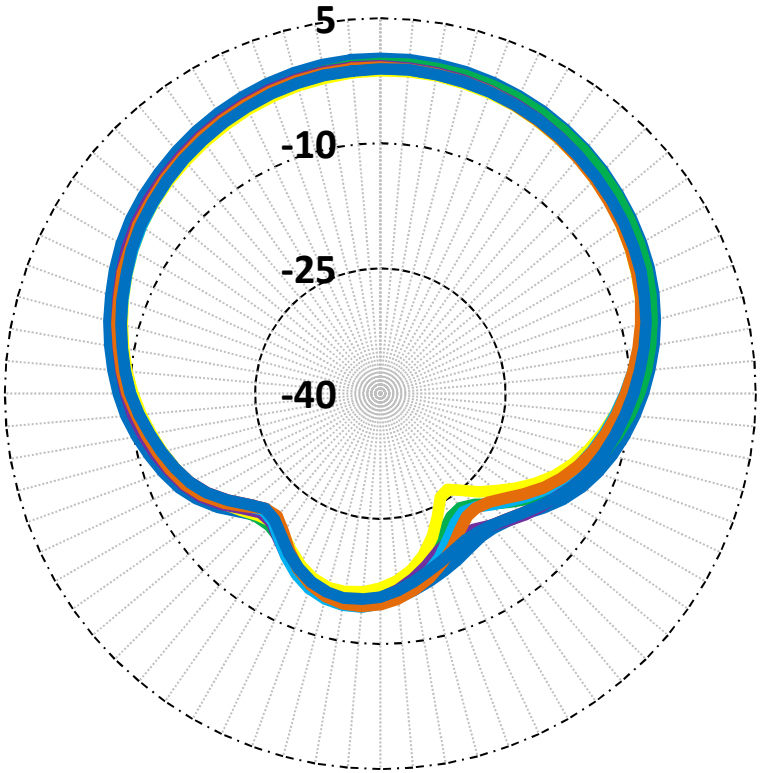
Radiation patterns of embroidered patch antennas

0.4mm stitch spacing



0.8mm stitch spacing



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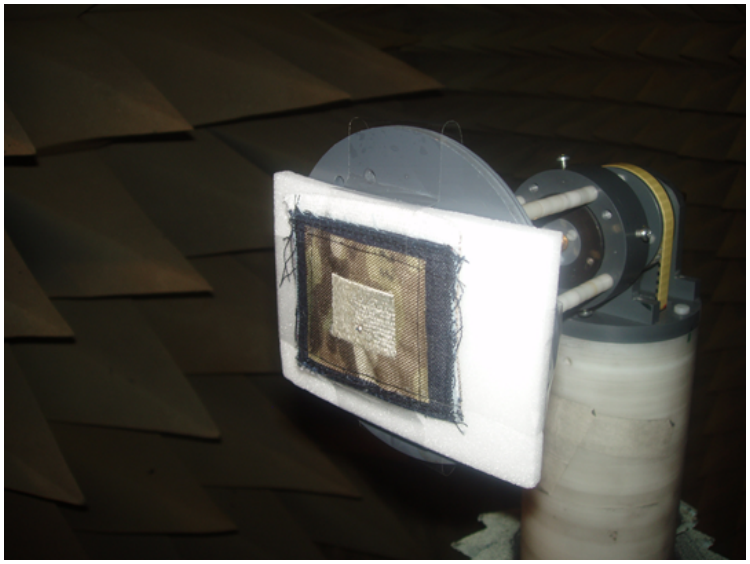
Summary

- **Fabricated 16 embroidered antennas**
- **Measured repeatability**



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Repeatability of Embroidered Patch Antennas

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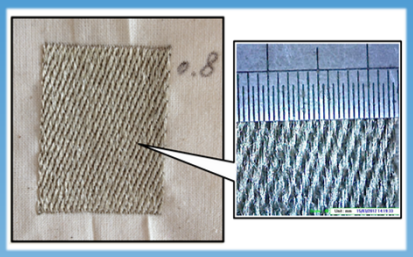
This study is focused on embroidering wearable antennas using conductive threads.

Digital embroidery machines allow antenna fabrication of single or mass-manufacture antennas that can be integrated into clothing.



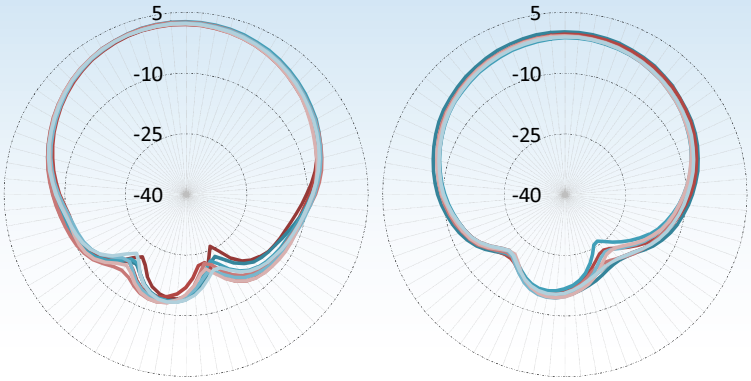
Two sets of 8 embroidered patch antennas with 0.4mm and 0.8mm stitch spacings were made

Measured results of 0.4mm stitch spacing embroidered antennas

Antenna number	Resonant frequency (GHz)	Peak gain (dBi)	Antenna efficiency (%)	10dB bandwidth (MHz)
1	2.383	2.3	30.2	73
2	2.418	2.0	27.9	86
3	2.460	2.2	27.4	116
4	2.380	2.8	34.1	86
5	2.403	2.4	30.4	110
6	2.348	2.5	31.4	90
7	2.458	2.1	28.0	111
8	2.348	2.1	28.1	72
Mean	2.399	2.29	29.68	93.00
Standard deviation	0.041	0.26	2.16	16.16
Etched copper	2.383	6.1	70.0	22

Measured results of 0.8mm stitch spacing embroidered antennas

Antenna number	Resonant frequency (GHz)	Peak gain (dBi)	Antenna efficiency (%)	10dB bandwidth (MHz)
1	2.110	0.1	20.8	73
2	2.075	0.2	22.1	53
3	2.043	-0.5	18.7	62
4	2.030	-1.7	16.1	74
5	2.088	-0.7	17.6	87
6	2.055	-1.8	15.4	75
7	2.068	-1.1	16.3	65
8	2.068	-1.4	14.6	34
Mean	2.067	-0.66	18.13	69.86
Standard deviation	0.024	0.57	2.36	10.12
Etched copper	2.383	6.1	70.0	22



Measured radiation patterns of 8 embroidered patches with 0.4mm stitch spacing (left) and 0.8mm stitch spacing(right)

SUMMARY

- The consistency of embroidery in antenna fabrication was tested
- Smaller stitch spacing offers higher antenna gain and efficiency
- The embroidery process lowers the patch antennas resonant frequencies
- The deviation can be improved by carefully choosing stitch spacing

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